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THE OCEANOGRAPHY OF JOHN ROSS'S ARCTIC EXPEDITION OF I8I8; A RE-APPRAISAL

by Rice A. L.

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G. 1954. Fauna of Strangford neighbouring coasts. Part 3. *Acad.* 56, 29–133.

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The oceanography of John Ross's Arctic Expedition of 1818; a re-appraisal

by A. L. RICE

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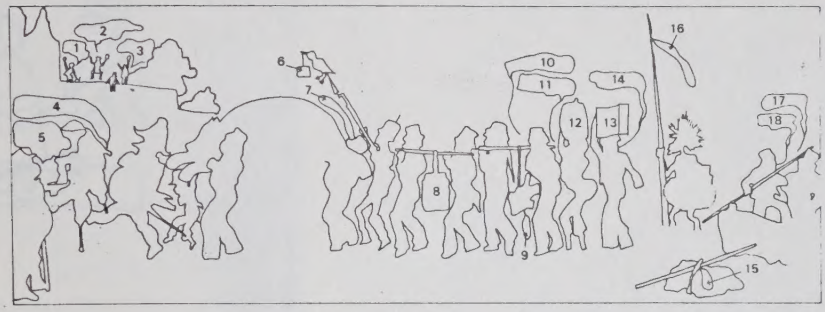
At this time, just over 100 years after the famous cruise of HMS *Challenger* laid the foundations of modern oceanography, it is fitting to look back at some of the earlier voyages which contributed to our knowledge of marine science. One such voyage was the Arctic Expedition of 1818 in HMS *Isabella* and *Alexander,* commanded by John Ross.

The voyage captured the public imagination at the time (see Plate I) and received a good deal of attention in later years, partly because it was the first of a whole series of Royal Naval expeditions in search of the north-west passage, and also because of the tremendous controversy which surrounded its return and which had repercussions lasting for several decades. The arguments centred around the geographical results which were the main objectives of the expedition, but a considerable amount of oceanographic information was also collected during the voyage. Unfortunately, in the months following the expedition's return the conflicts overshadowed the scientific achievements, so that they were largely ignored and their significance was not appreciated until many years later. If the results had been examined closely at the time it is possible that two erroneous theories which dominated marine science during the middle years of the 19th century would have been discredited much sooner than they actually were.

For Ross was convinced that his sounding line had brought up living creatures from a depth of 1000 fathoms[1], much deeper than the limit of 300 fathoms or so which was favoured by followers of the famous 'Azoic' theory developed by Edward Forbes during the 1840's and 50's. Similarly, some of the sub-surface temperature readings were much lower than those to be expected according to the 4°C theory which was based on the misconception that sea-water, like fresh water, has a density maximum at this temperature[2]. By the time the 1818 results were resurrected they were only of historical interest, since subsequent work had demonstrated the existence of life at much greater depths and also shown up the fallacy of the 4° theory. When the *Challenger* sailed in 1872 Ross's results were simply accepted at their face value, and in almost every review of the history of oceanography since that time, including the introduction to the *Challenger* Report itself, they have been repeated in the same uncritical way. The purpose of this paper is to attempt to rectify this situation, at least as far as the deep soundings and the temperature measurements are concerned.

THE BACKGROUND TO THE VOYAGE

The events which led up to the Arctic Expedition, the voyage itself and the personal feuds and alliances which resulted from it, have been adequately documented in recent years so that only a brief summary is necessary here[3].



Key to Plate I

1. Hurra! they have got *Eursa major.* as I live! Hurra!
2. I see it! I see it! the North Pole by Jupiter!! I'll cling to it like a *leech.* Hurra! hurra!!
3. I see Jack Frost! I see Jack Frost! Hurra! with the N. Pole in his hand!! Hurra.
4. O. Captain he is come to town, doodle doodle Dandy How you do Sir, hope see you well Sir?
5. I think as how we have *Bears, Gulls, Savages, Chump wood, Stones* & Puppies enough without going to the North Pole for them.
6. ————? Sabini.
7. 'tis a good thing I've lost my Nose.
8. RED SNOW for B.M.
9. Esquimau wood for B.M.
10. I say Snowball, mind you don't tread on my heels.
11. No, No, Massa Billy! & Mind you no tread my toes!
12. WORMS found in the Intestines of a Seal by a Volunteer for Brit. Mus.
13. Moluscoe for the British Museum.
14. who the hell's to carry the big stone?!!
15. GRANITE for B.M.
16. Lance made of Horn of Sea Unicorn used in common as a walking stick.
17. If they kill the Dogs & stuff em! what will they do with Jack Frost?
18. Cut his throat, & Stuff him also I supposes.

The end of the Napoleonic wars had left Britain with a large and under-employed Navy and the urgent need, at least in Admiralty eyes, for worthwhile peacetime uses for both ships and men. After a foray into African exploration with the disastrous Tuckey expedition to the Congo in 1816, John Barrow, the influential Second Secretary to the Admiralty from 1803 to 1845, was anxious to redirect the Navy's attention to other regions. His chance came in 1817 with the reports of returning whaling captains that the waters around Greenland were unusually free from ice. The most important report was that of William Scoresby junior whose conclusion that the time was now ripe to re-open the old search for the north-west passage between the Atlantic and the Pacific was enthusiastically accepted by Sir Joseph Banks, President of the Royal Society. Banks's letter to the First Lord of the Admiralty, Lord Melville, was favourably received and the intention to mount such an expedition was announced in late November 1817.

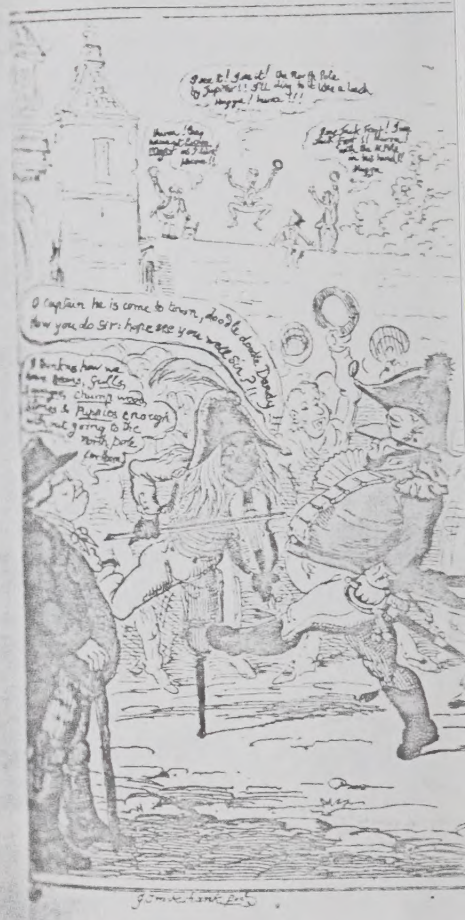


Plate I. Cruickshank cartoon "Lan
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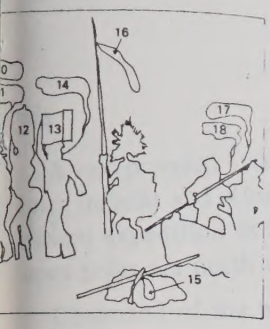

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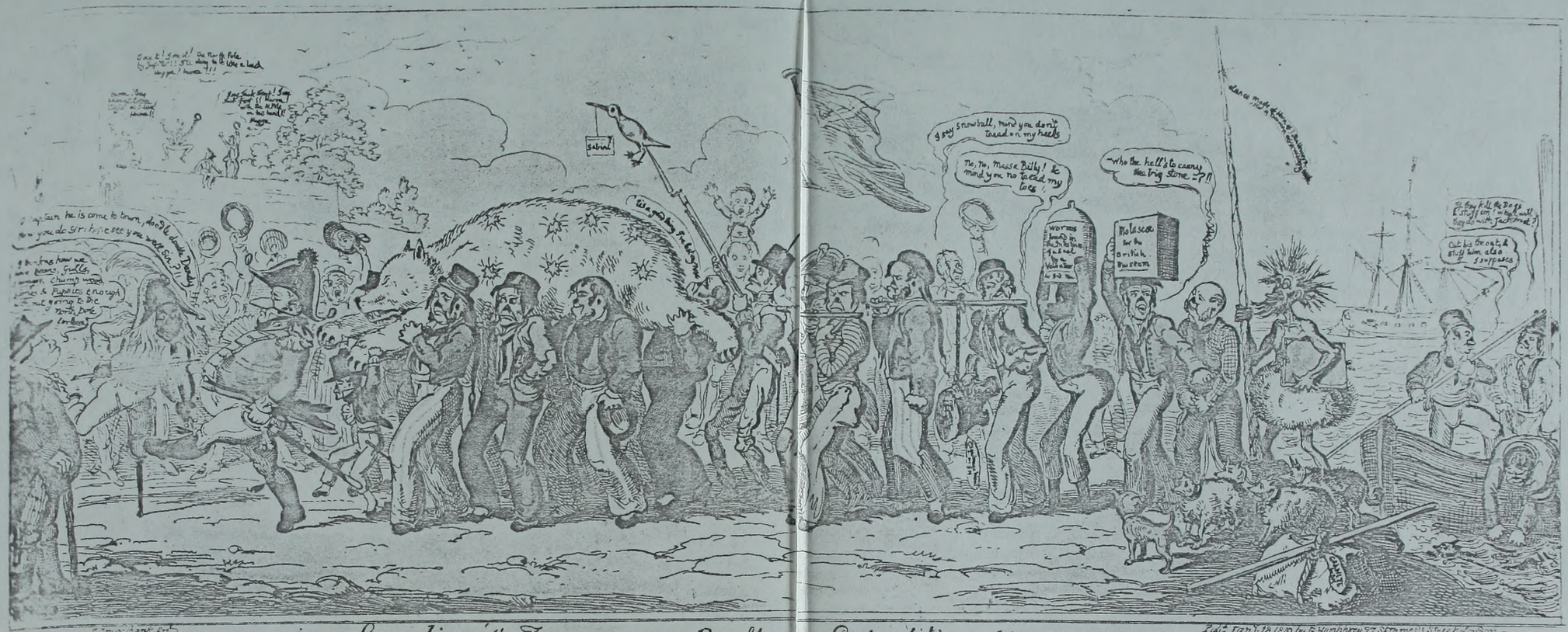

Plate I. Cruickshank cartoon "Landing the treasures . . . . ", published on January 18th, 1819. Reprermission of the Trustees of the British Museum.

A procession, headed by John Ross, extends from the coast towards the British Museum, the part sho front of Montagu House, in Great Russell Street, which was demolished in 1860. The sentry represents the picket with which the Museum was provided until 1863. On the wall of the Museum are Sir Jose lding the top of the ladder) and Dr. W. E. Leach, a naturalist on the staff of the B.M., who examined the expedition's zoological collections.

Ross is followed in the procession by young James Clark Ross and, further back, by the military figur Sabine carrying a bird on his bayonet. This is Sabine's gull, *Larus sabini*, collected by Edward and sent back from Greenland to his brother Joseph who described the new species in the Transactions of the iety for 1819. The type specimen is now in the collections of the British Museum (Natural History), but during his lifetime it was retained by Edward Sabine and only came into the Museum's possession afte 1883.

More information about this cartoon can be found in M. D. George (1949). *Catalogue of political and ires preserved in the Department of Prints and Drawings in the British Museum,* Vol. IX, 1811–1819. London.

A two-pronged attack on the Arctic was to be made, with a western expedition in the brigs *Isabella* and *Alexander* seeking a north-west passage from Baffin's Bay, while an eastern expedition in the *Dorothea* and the *Trent* was to attempt to reach the expected open polar sea north of Spitzbergen.

Command of the western expedition was given to John Ross, a 40-year-old Commander with over 30 years of sea going experience since he had joined the navy at the age of 9 in 1786. Ross had gained some experience of ice navigation in the Baltic and White Seas while serving under Admiral Sir James Saumarez and he was certainly better qualified for Arctic exploration from this point of view than was his second in command, Lieutenant William Edward Parry[4]. Nevertheless, Parry was soon to become much more celebrated than Ross as an Arctic explorer, partly as a result of his good fortune in encountering favourable ice conditions during the second Naval Arctic expedition of 1819–1820.

The *Isabella* and *Alexander* also carried a number of other naval officers whose names crop up again and again in the story of polar exploration over the next few decades. Principal amongst these was Ross's 18-year-old nephew, Midshipman James Clark Ross, who had served with and under his uncle since joining the navy in 1812. Like Parry, the younger Ross was also destined to have a more widely acclaimed career as a polar traveller than his uncle, making a long series of expeditions culminating in his command of the *Erebus* and *Terror* in the Antarctic during 1839–1843.

In its primary aim, the discovery of a northwest passage, the 1818 voyage was not a success, for after leaving the river on 18 April 1818 the two ships circumnavigated Baffin's Bay without finding a suitable outlet either to the north or west. Nevertheless, on their return in November the results seemed sufficiently encouraging to warrant sending a second expedition, again under Ross, in the following year, and Ross was promoted Post Captain on 7 December in recognition of his work. But by the time the *Hecla* and the *Griper* sailed in April 1819 Parry was in command, while Ross was left on half pay, never again to be employed by the Admiralty. For in the meantime he had become the centre of a controversy which resulted in a personal animosity between himself and Barrow which lasted until the latter's death in 1848, and remained at such an intensity that even as late as 1846 Barrow wrote about Ross in extremely vitriolic terms[5].

The arguments eventually focused on the Croker Mountains, a non-existent range which Ross maintained blocked off Lancaster Sound and which he named after the First Secretary to the Admiralty. Before the 1818 voyage this sound was widely expected to offer the best hope of a route to the west, an expectation which was realised when Parry sailed through the Croker Mountains in the *Hecla* and *Griper* in 1819, replacing them by Barrow's Strait!

Ross had claimed that he saw the mountains during a short period of good visibility in the afternoon of 31 August, 1818, and he was able to produce a sketch of the land before the fog closed in once more. But his officers in the *Isabella* were below at the time and the *Alexander* was several miles astern, so that, apart from the helmsman and the Greenland pilot, Ross had no other witnesses to his reason for abandoning the search and turning south. In the absence of the evidence of their own eyes, few if any of the other expedition members shared Ross's opinion of the land-locked nature of Lancaster Sound, and it is this mistake for which Ross is mainly remembered and which has usually been thought to be the reason for his failure to obtain another naval command.

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But as Jones has pointed out, the initial cause of the trouble following the expedition's return was not the Crok[illegible] at all. Rather it was Ross's failure to give proper credit for the scientific observations to the officers concerned, and particularly to Edward Sabine, a 29-year-old Royal Artillery Captain who sailed as supernumerary on the *Isabella* on the recommendation of the Royal Society.[4]

For the voyage was very definitely a scientific one, and in his "*Chronological history of voyages into the Arctic regions* . . . . .", published as the *Isabella* and *Alexander* left England, Barrow went to great lengths to point out that the current search for a north-west passage was not prompted by the commercial pressures which had spurred on the 16th and 17th century navigators in the same quest. On the contrary, the ships were equipped with the very latest instruments to ensure that the expedition was a success as a scientific enterprise so that "whatever new discoveries may be made, may be for the general benefit of mankind"[6]. Nevertheless, there was a considerable element of national pride too, for it was supremely important that these discoveries should be given to the world by England rather than by any other nation. "It would have been something worse than indifference, if, in a reign which stands proudly pre-eminent for the spirit in which voyages of discovery have been conducted, England had quietly looked on, and suffered another nation to accomplish almost the only interesting discovery which remains to be made in geography, and one to which her old navigators were the first to open the way".[7]

This refers, of course, to the northwest passage itself and the improved charting of Greenland and North America, but Ross's official instructions from the Admiralty made it clear that his objectives did not end here. For after specifying his duties in this direction they continue ". . . Although the first, and most important, object of this voyage, is the discovery of a passage from Davis' Strait . . . ; it is hoped, at the same time, that it may likewise be the means of improving the geography and hydrography of the Arctic Regions, of which so little is hitherto known, and contribute to the advancement of science and natural knowledge."[8] In particular Ross was to make a variety of magnetic and meteorological observations, but he was also instructed to carry out a comprehensive programme of what we would now call oceanography. He was, for instance, " . . . to attend particularly to the height, direction, and strength of the tides, and to the set and velocity of the currents; the depth and soundings of the sea, and the nature of the bottom . . . " He was also " . . . to collect and preserve such specimens of the animal, mineral, and vegetable kingdoms, as you can conveniently stow on board the ships . . . " (see Plate I). "In this", wrote their Lordships, "as well as in every other part of your scientific duty, we trust that you will receive material assistance from Captain Sabine . . ." who was " . . . a gentleman well skilled in astronomy, natural history, and various branches of knowledge, to assist you in making such observations as may trend to the improvement of geography and navigation, and the advancement of science in general".

For Sabine this was the beginning of a very distinguished scientific career in which he eventually received the ultimate accolade of the Presidency of the Royal Society. But in 1818 he was not particularly well qualified for the task he was placed on the *Isabella* to do. Nevertheless, he had been assiduously studying various aspects of science for some months and had managed to impress Sir Joseph Banks sufficiently to obtain his all-important support in obtaining employment in the new expedition. Sabine certainly worked concientiously during the voyage, particularly at the magnetic observations, and

it was especially the attribution of this work to James Clark Ross in the published narrative which sparked off the great controversy[9]. But John Ross was rather critical of Sabine's performance in some other areas of the scientific work, and especially in zoology and mineralogy, indicating that the quality of the expedition's results in these subjects suffered from Sabine's lack of interest or expertise. These criticisms were perhaps not justified, for even in the early nineteenth century it was unreasonable to expect a man as young as Sabine, and particularly one with an active military career behind him, to be expert in all the disciplines involved in a voyage of this kind. On the other hand, a letter sent from the *Isabella* on 26 July 1818 to his brother Joseph indicates that Sabine, in his turn, was somewhat scornful of Ross's enthusiasm for collecting scientific material.

"Ross asked me yesterday if he could write in my favour to any public people – It is very obliging of him. I told him no not at present – that I hoped to get promotion thro' Lord Melville on my return. He said he had of course written about me to Lord Melville, but that he should be ready to do so any time to Lord Mulgrave or to any other person. He is very kind and I am really half ashamed of myself for laughing at his stupidity in collecting *mud,* and packing it in pickle jars, and in glass tubes *hermetically sealed,* and in conceiving that he is doing Sir Joseph Banks great service in supplying him with it."[10]

Ross was clearly anxious to collect all manner of oceanographic data and there is little doubt that it was through his efforts rather than those of the other officers that the expedition obtained as much information as it did. Unfortunately, as we shall see, his enthusiasm was not matched by his care in recording the observations, the reliability of which are therefore often in doubt.

THE SOUNDINGS

The deepest reliable sounding in which material was brought back from the sea-bed prior to the voyage of the *Isabella* and *Alexander* is usually considered to be that taken by Capt. Constantine Phipps in 683 fathoms to the east of Iceland from HMS *Racehorse* in 1773. In the intervening years few soundings had approached even this fairly modest figure, for the making of deep soundings from a sailing ship with only manpower to operate the gear was tedious and time-consuming, and in any case most seafarers were interested in water depth only in so far as it might indicate the proximity of land or some other navigational hazard.

Nevertheless, in accordance with his instructions Ross conscientiously took soundings at fairly frequent intervals and in his narrative he lists over 100 obtained while the ships were in Baffin's Bay. The great majority recorded depths of less than 400–500 fathoms, but 8 were much deeper. Four of these were in the depth range 650–687 fathoms and, although quite deep for that time, would probably not have attracted further comment. But the remaining four soundings, apparently between 1000 and 1070 fathoms, ensured for Ross a place in almost every subsequent account of the history of oceanography.

A re-evaluation of the results after the passage of 150 years is not easy, partly because the published and manuscript accounts do not agree in all details. But before examining these accounts it is necessary to tackle two other problems; firstly to try to determine the techniques that were used for the soundings, and secondly to establish the degree of reliance that can be placed on the localities given for them.

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SOUNDING TECHNIQUE

The simplest and oldest method of sounding the depth of the sea is to lower a heavy weight on the end of a line marked at regular intervals along its length. With the line as near vertical as possible, the mark nearest to the water surface when the weight is on the bottom gives a reasonable estimate of the depth. To obtain some idea of the nature of the bottom the weight may be 'armed' with a thick coating of soft tallow on its lower end. On reaching the sea floor a small sample of the sediment will stick to the tallow and be brought to the surface with the weight.

This simple technique is still used today, although it has been largely superceded by echo-sounding and by more efficient bottom sampling instruments. But in the early 19th century it was still the main method of sounding, and the list of equipment published with Ross's narrative shows that he had with him three "deep-sea leads" of 50, 100 and 150 lbs respectively, and large quantities of 2½ inch whale line.

During the preceding few decades there had been several attempts to produce quicker and more efficient instruments for sounding in fairly shallow water. One such device was Burt's buoy and knipper with which Ross was also provided. This instrument was designed to enable soundings to be undertaken from a ship under way and was adopted for general use by the Royal Navy in 1818[11]. Ross found it satisfactory, but its use was restricted to depths of 100 fathoms or so and he reported that "owing to the water being generally above 150 fathoms, we had little opportunity of using it".[12]

In any case Burt's buoy and knipper was not designed to bring up samples of the bottom, although the lead used with it could be armed like a conventional one. But Ross, according to his instructions, took with him an instrument " . . . better calculated to bring up substances than the lead usually used for this purpose".[13]

There is no description of this new instrument which, according to a comment in Ross's Meteorological Journal for 21 July 1818 (see later), was invented by Dr John McCulloch. McCulloch wrote the short geological appendix to Ross's narrative, prefaced by some remarks on how poorly documented the collection of specimens was. He did not, however, mention his sea bed sampler, nor did he examine the bottom samples collected by the expedition.

But whatever McCulloch's sampler was like, it was not very effective, for during the early part of the voyage "many fruitless attempts had been made to procure substances from the bottom of the sea in deep water". Accordingly, in his narrative entry for 14 July 1819 Ross writes " . . . I employed some of my unoccupied time in constructing an instrument for bringing up substances from the bottom of the sea, to supply the place of our machine which, from its defective workmanship, had been found ineffective, particularly in deep water. Our Smith's forge was set-up, and an instrument made after my model, on an entirely new principle, which answered extremely well".[14]

On 25 July Ross dispatched a letter to Croker at the Admiralty, informing the First Secretary of his invention and enclosing drawings of it produced by Midshipman Skene. (Plate II).[15] The instrument consisted of a cylindrical cast iron weight with a rectangular cross-section, which was supported during the descent to the sea-bed by the open jaws of a pair of "forceps" protruding beneath the weight. The jaws were held open by a hinged bar carrying a spindle extending between and beyond the jaws so that this was the first part to touch the bottom. When this happened the hinged bar was

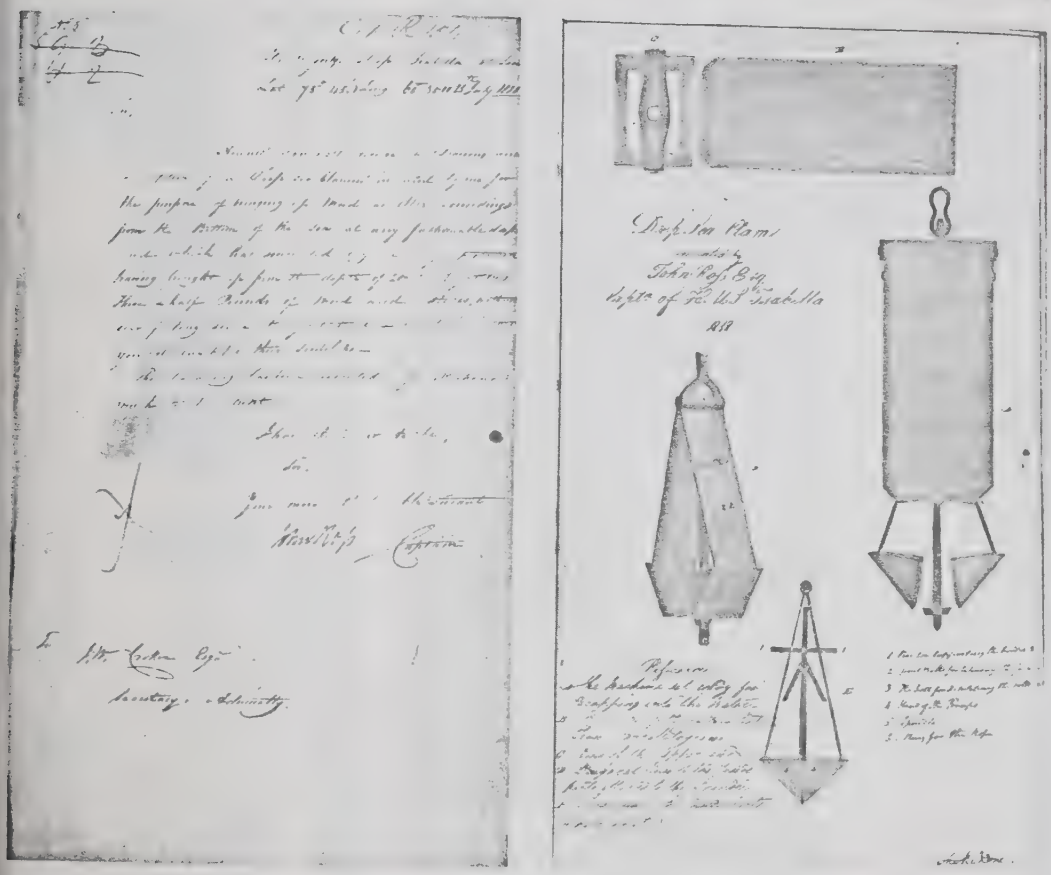

Plate II. Ross's letter to the First Secretary to the Admiralty (Public Record Office, ADM 1/2429) written aboard the *Isabella* on July 25th, 1818, together with Midshipman Skene's sketches of the newly invented "deep-sea clamm".
Reproduced by permission of the Keeper of the Public Records.

"tripped" and the weight was able to slide down the jaws, clamping them together and enclosing a sample of the bottom sediment (see also Plate III).

By the time Ross wrote to Croker the instrument had already been tried, for in the narrative for 21 July he writes "My newly-invented instrument for bringing up substances from the bottom of the sea, being now finished by the armourer, who was an excellent mechanic, I ordered it to be tried; we were in smooth water, moored to the ice. The instrument was lowered into the sea by a whale line of two and a half inches, and in about six minutes it reached the bottom (at 220 fathoms); and, on being hauled up, contained between three and four pounds of mud and stones. The name I gave to this instrument . . . was the Deep-Sea Clamm".[16]

The rectangular cylinder of this first 'clamm', according to Ross's description, weighed one hundredweight, so that with the jaws and tripping bar the whole instrument must have weighed nearly 150 pounds. He suggested, however, that smaller versions might be made for use in shallower water, one of 50 pounds being recommended for the North Sea.[16]

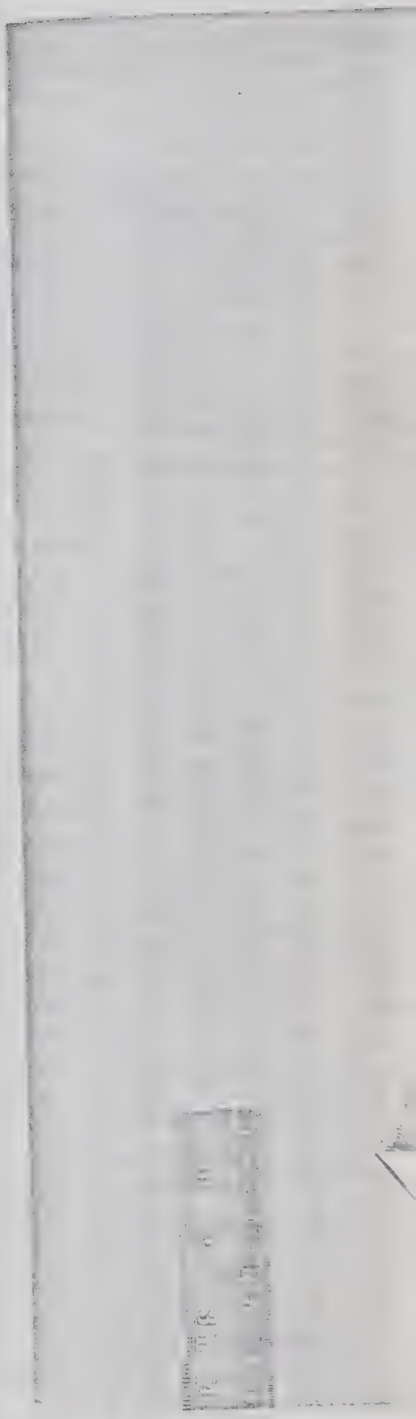

Plate III. Brass model of Ross's Deep-
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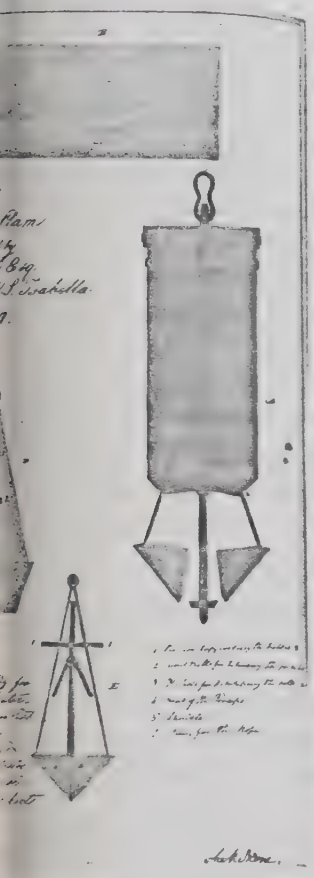

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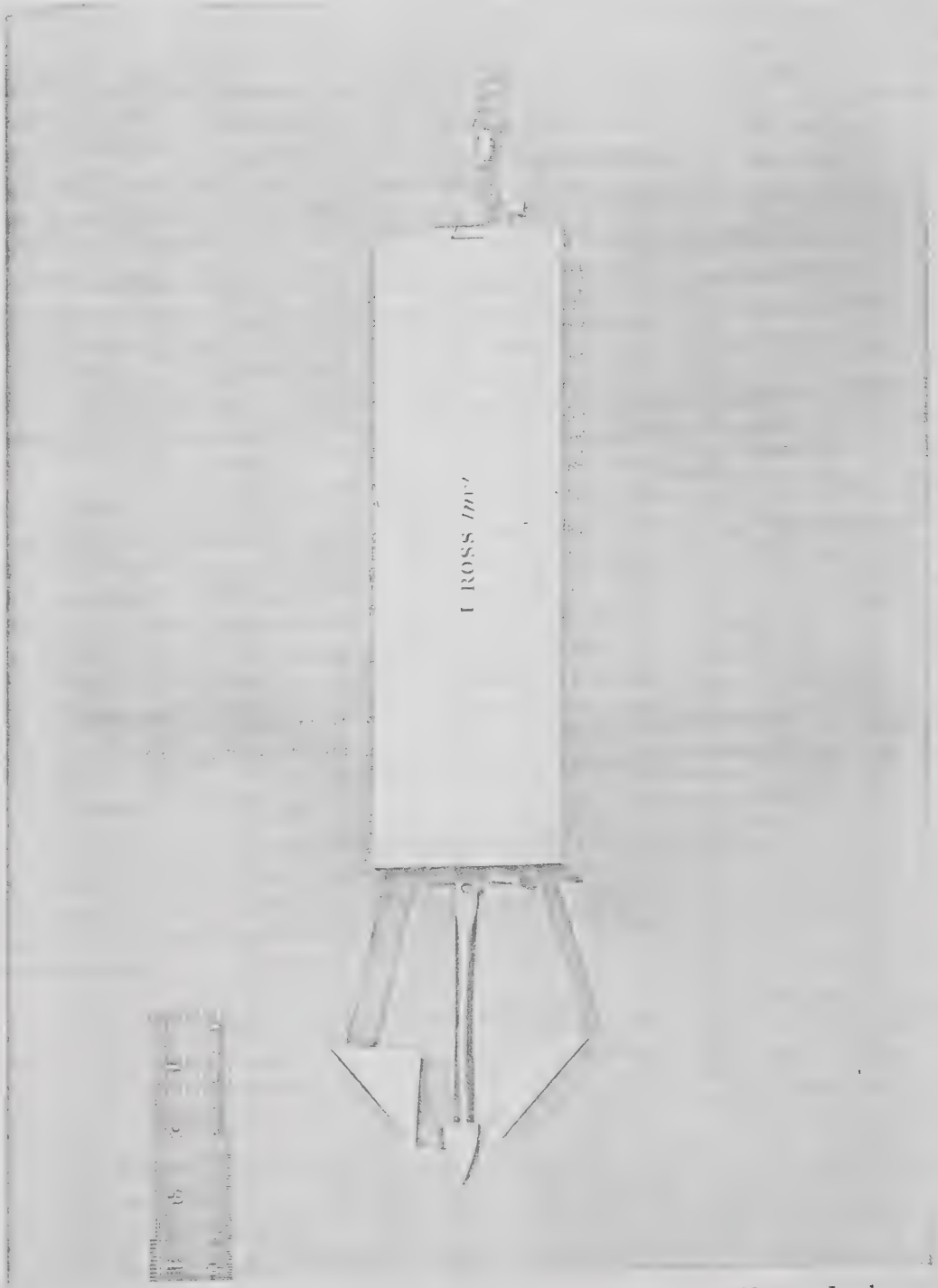

Plate III. Brass model of Ross's Deep-sea clamm in the collection of the Science Museum, London (Inv. 1876–831). This model was presented to the Museum by the Hydrographic Department of the Admiralty in 1876, but its earlier history is unknown. It is just possible that it is the one originally presented by Ross to the University of Edinburgh Museum, but now apparently missing from the collections of the Royal Scottish Museum (see Sweet, J. M., 1974, "Robert Jameson and the explorers: The search for the North-West passage. Part I," *Ann. Sci.*, 31: 21–47.)

With his published description Ross also gives some very brief details on how the clamm should be used. "In very deep water", he writes, "it is necessary that it should be calm or nearly so, to be certain that soundings are obtained in 500 fathoms; but, in a light breeze, the instrument may be hung to a boat and towed in the direction of the ship's drift, and if there is any wind it is best to lower all the sails down. An out-rigger, fitted with a block, should be fixed on the weather-quarter, through which the line ought to be rove and bent to the instrument, when it ought to be lowered until it is a fathom below the surface, and then let go".[18]

Ross was obviously aware of the problems in obtaining accurate soundings caused by the drift of the ship, though it is not clear how his suggested use of a boat moored to the main vessel would overcome this. In any case there is no indication either in his narrative or in the available logs that a small boat was ever used for this purpose on the expedition, and the effective use of longboats to counteract both wind and surface current drift seems to have been introduced over 20 years later by James Clark Ross in the *Erebus* and *Terror*[19].

The other main difficulty in sounding in deep water was to determine precisely when the lead or sounding instrument reached the bottom. For even after this had occurred the weight of the rope alone would continue to carry it over the side of the ship, though at a somewhat slower rate. The aim was to recognise this "check" when the rate changed, and to do this some system of timing was necessary. Again, it seems to have been James Clark Ross who introduced the accurate timing of the passage of each 100 fathoms of the sounding line, though even with such detailed data it was easy to miss the check in very deep water[20]. Although, as we shall see, John Ross did make some attempt to note the speed at which the sounding line ran out, he does not seem to have been particularly systematic in this, and the detection of the rate change probably depended on someone simply watching the line pass over the side.

In summary, then, Ross's deep soundings seem to have been taken either with a deep-sea lead or with the clamm, weighing between 100 and 150 pounds. The sounding instrument was lowered from the *Isabella* on a 2½ inch hemp whale line, presumably running through a block rigged outboard on a spar. Finally, the arrival of the instrument on the sea-bed was determined visually.

THE POSITIONS OF THE SOUNDINGS

Before the *Isabella* and the *Alexander* sailed, Baffin's Bay was virtually unmarked on Admiralty charts, for Baffin's own description following the voyage of the *Discovery* in 1618 was so imprecise that his work had become largely disregarded. Ross was therefore sailing into almost totally unknown waters with no fixed reference points within hundreds of miles. Secondly he had to contend with frequent poor visibility making astronomical fixes irregular and difficult, and finally there were the problems of using a magnetic compass in high latitudes 10 years before his nephew was able to establish the position of the magnetic pole.

Despite these difficulties, Ross came back with what must be considered a tolera[ble] good first attempt to chart the Bay, with the notable exception of the Sounds to the

rth and west, of course. The handsome manuscript chart, constructed by Midshipman [illegible]nam and presented to the Admiralty, is still preserved in the Hydrographic Office[21], and a tracing of that part of it covering the deep soundings, from Lancaster Sound in the north to Cumberland Sound in the south, is superimposed on a modern chart of the same region in fig. 1. This shows that the coastline according to Ross is generally displaced from its presently accepted position some 15–30 miles to the southeast. Since the chart was based largely on bearings and distances from presumed ship positions, these must be similarly erroneous, so that the co-ordinates which Ross gives for the Soundings cannot be relied upon. The errors probably arose because Ross placed too much reliance on the log and chronometers. Parry consequently thought that Ross's survey was "wretchedly manufactured" and he spent some time in the *Hecla* and *Griper* during 1820 recharting the western coastline of Baffin's Bay[22]. But despite the shortcomings of Ross's charting technique, his results were much more accurate and detailed than the manuscript charts which were produced at the same time by Parry on the *Alexander* and which are also in the Hydrographic Office (fig. 1)[23].

Since Ross's latitudes and longitudes are not acceptable, the probable positions of the deep soundings must be determined by some other means. Because of the difficulty of using the magnetic compass near the poles Ross went to great lengths to measure not only the variation but also the *deviation* due to the iron in the ships, swinging the ships' heads onto all compass points to measure this both in Baffin's Bay and at Shetland. He also says that " . . . the bearings of the land were always found correctly by placing the ship's head on to the northern or southern points of change", that is the direction in which there was no deviation in either direction. It seems, then, that the best available means of fixing the positions of the soundings is to use the bearings and estimated distances from the nearest land, despite the fact that these are not always based on sightings.

SOURCES OF INFORMATION ON THE DEEP SOUNDINGS

The four deep soundings were all taken within a few days of one another as the ships left Lancaster Sound and sailed southwards down the western side of Baffin's Bay and Davis Strait. There are several accounts of the events of this part of the voyage, the most detailed one being in Ross's published narrative already referred to[24]. The text of the narrative is based very largely on Ross's copious 'Private Remarks' in his Meteorological Journal and Sea Log[25]. In turn, the log part of this document is based on the Rough Deck Log of the *Isabella*[26].

Two further manuscript journals produced by members of the *Isabella's* complement are extant, those of Lieutenant Robertson[27] and Captain Sabine[28].

Various records of the voyage from the viewpoint of the *Alexander's* personnel are also available, including a published account by the Assistant Surgeon Alexander Fisher[29], Parry's Captain's Log[30], his personal journal[31] and the *Alexander's* meteorological log[32]. However, since all of the deep soundings were made from the *Isabella*, any comments about them in these *Alexander* documents must be at second hand and they are therefore not used regularly in the following examination.

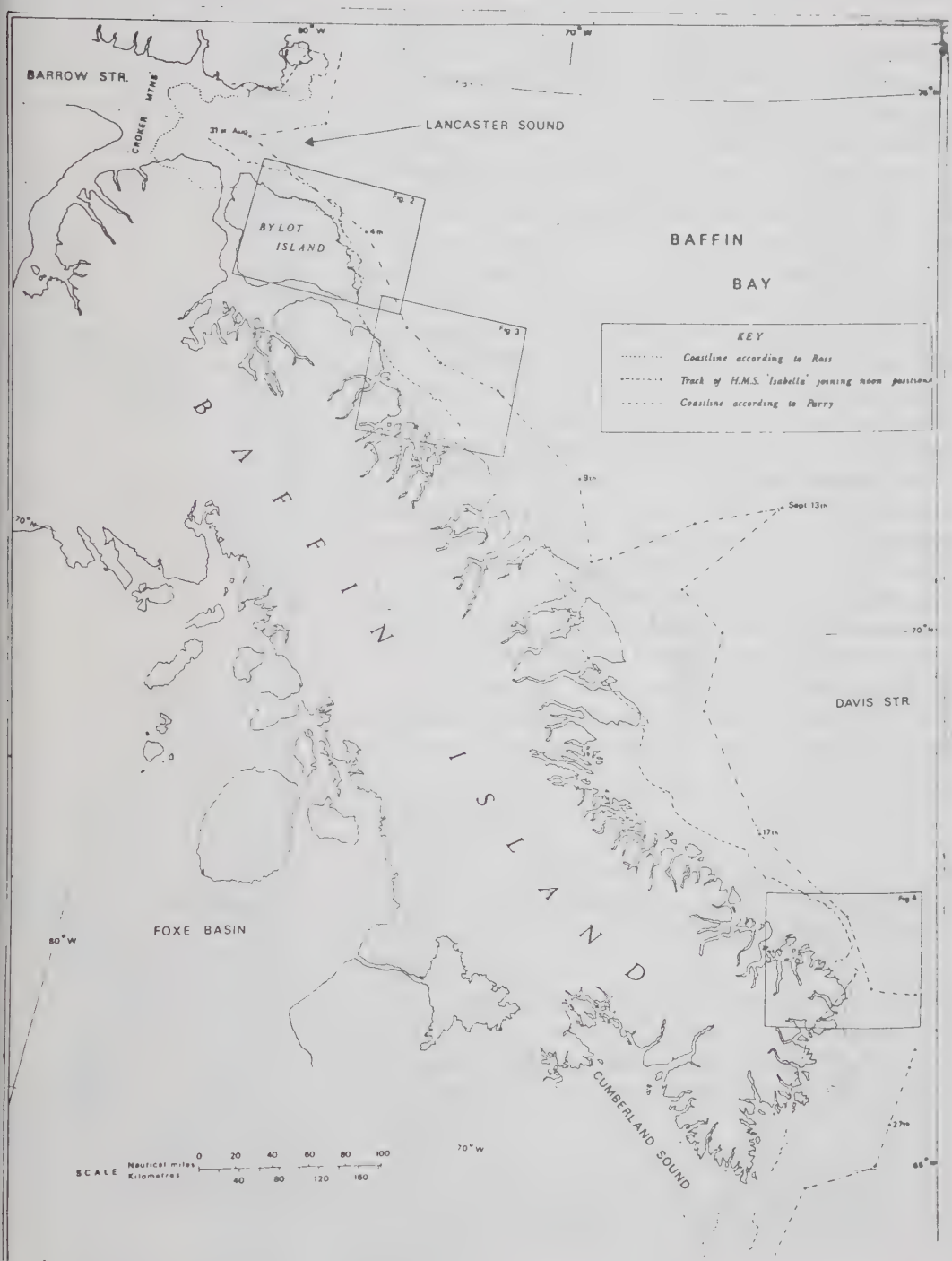

Figure 1. John Ross's chart (see note 1) of the coastline of Baffin Island from Lancaster Sound to Cumberland Sound superimposed upon a modern chart of the same region. The track of the *Isabella* is not a detailed route, but simply joines noon positions.
Parry's version of portions of the same coastline (see note 23) is included for comparison.
The areas covered by figs. 2, 3 and 4, which include the sites of the deep soundings, are also indicated.

SOUNDING 1

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and described the afternoon's activ

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the current, and the temperature
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found a beautiful caput medusae;
described in the Appendix. To ob
the transit bearings of two objects
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surface was at 34½°, and at eight
had been broken; it could not be
was tried, however, at two hundr
29½°. These objects being obtain
breeze springing up from the east
the distance of two miles from th
fifty fathoms, and the clamms br

At six the boats returned with
kingdoms."

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Journal, for instance, his account
words.

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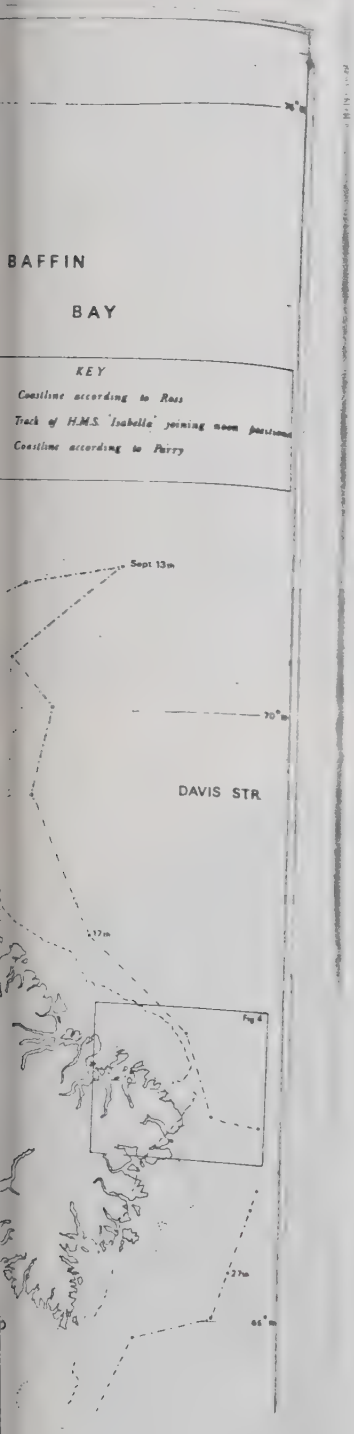
got up about two and a half pou
caput medusae which has been c
miles of the shore and had four
shrimps".

In the log part of this journal
but it does appear in the sound
presumably transcribed, the left
together with the complete entr
Croker Mountain![33]

Robertson's journal is extre
Ross's published account.

"Sounded in 1000 fatho
Sounded in 450 fathoms



from Lancaster Sound to
The track of the *Isabella*

or comparison.
soundings, are also

SOUNDING 1

The first 1000 fathom sounding was taken on the afternoon of 1 September, 1818, less than 24 hours after Ross had given up the search for the north west passage in Lancaster Sound. As the ship sailed out of the Sound and past what is now known as Bylot Island a landing party was put ashore at Possession Bay. Ross remained aboard the *Isabella* and described the afternoon's activities in his narrative.

" . . . at one, the boats were despatched, under the orders of Mr Skene and Mr Ross, to take possession of the country. Captain Sabine . . . went on shore with the Surgeon and his Assistant to collect specimens of natural history; . . . They landed at about two o'clock, . . . In the meantime I was employed on board, in sounding and trying the current, and the temperature of the water. It being perfectly calm and smooth, I had an excellent opportunity of determining these important objects. Soundings were obtained correctly in one thousand fathoms, consisting of soft mud, in which there were worms; and, entangled on the sounding line, at the depth of eight hundred fathoms, was found a beautiful caput medusae; these were carefully preserved, and will be found described in the Appendix. To observe the current, the line was again dropped over, and the transit bearings of two objects on the land set; these, however, did not vary in the least, nor did we find any current by the line . . . The temperature of the water on the surface was at 34½°, and at eighty fathoms 32°; but as our self-registering thermometer had been broken; it could not be ascertained on board the *Isabella* at a greater depth; it was tried, however, at two hundred and fifty fathoms in the *Alexander*, and found to be 29½°. These objects being obtained, views were taken of the land; and at five, a light breeze springing up from the eastward, I stood into the bay to pick up the boats; and, at the distance of two miles from the shore, we hove to, and sounded in four hundred and fifty fathoms, and the clamms brought up some stones and gravel, and two small shrimps.

At six the boats returned with many specimens of the animal, vegetable, and mineral kingdoms."

Those parts of this passage which refer specifically to the sounding agree very closely with the manuscript documents. In Ross's "Private Remarks" in the Meteorological Journal, for instance, his account of the shore excursion is followed by the following words.

"At the distance of six miles from the shore we sounded in one thousand fathoms and got up about two and a half pounds of soft green mud and at the same time a beautiful caput medusae which has been carefully preserved – we sounded afterwards within two miles of the shore and had four hundred and fifty fathoms gravel, stones and two small shrimps".

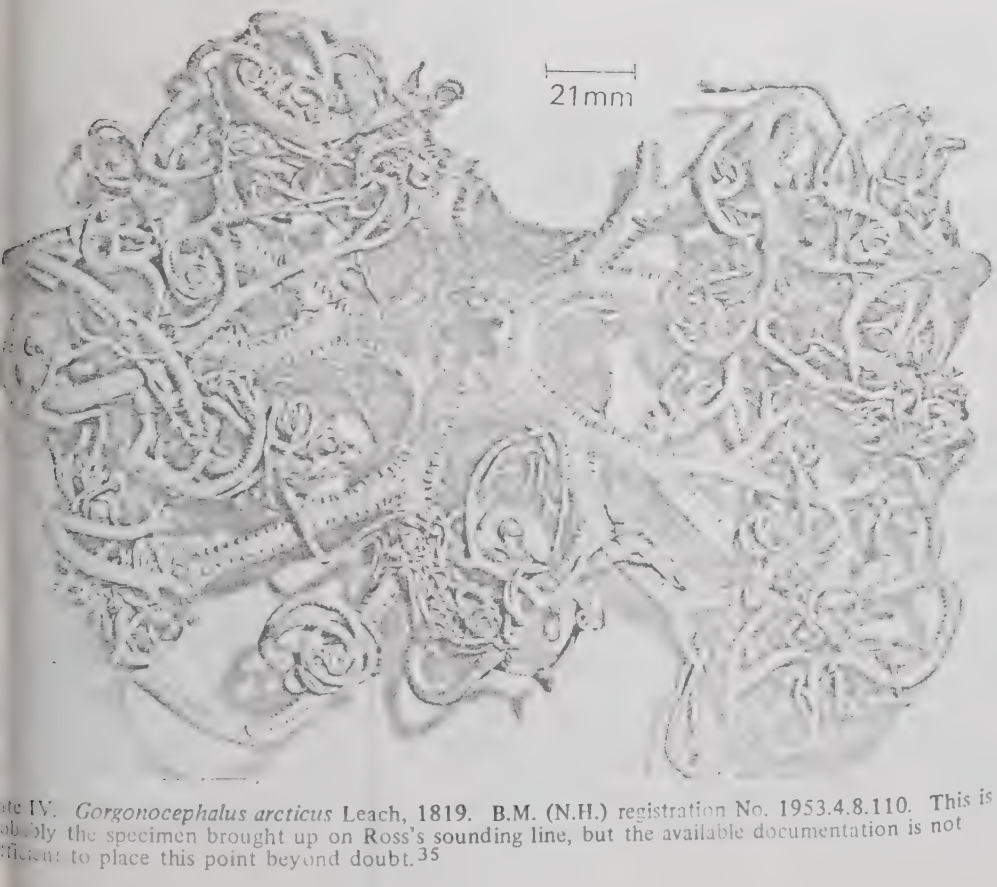
In the log part of this journal there is no mention of this sounding under "Remarks", but it does appear in the sounding column. In the Rough Deck Log from which this was presumably transcribed, the left hand folio, including the sounding column, is missing together with the complete entry for 31 August, the day Ross "saw" the controversial Croker Mountain![33]

Robertson's journal is extremely brief, but there is nothing in it which contradicts Ross's published account.

> "Sounded in 1000 fathoms soft mud, distance offshore 6 miles . . .
> Sounded in 450 fathoms soft mud and small stones distance offshore 2 miles".

In many ways this first deep sounding is the most interesting of all, partly because of the retrieval of the 'caput medusae', since this was later accepted as the first clear demonstration that life exists at great depths in the sea.[34] But Ross's reference to this fact alone is sufficient to cast doubts on the accuracy of the sounding. For this starfish, now known as *Gorgonocephalus arcticus* (Plate IV), is definitely a bottom living species and could not possibly have been floating 200 fathoms above the bottom.[35] The sounding line at the 800 fathoms mark must therefore have been dragging on the sea-bed and this immediately puts an upper limit on the depth of water.

But this sounding is also somewhat easier than the rest to position reasonably accurately because the *Isabella* was so close inshore. In his text Ross does not mention a distance from the land, but in the table of soundings published with the narrative he says that Possession Bay was six miles to the south, the figure given in all the other accounts except that of Sabine who, as we shall see, changed his mind from 1–2 miles to 4–5 miles. It seems very unlikely that distances of this order could have been grossly underestimated, but even if the ship was as much as 10 miles from the shore of Possession Bay there is no indication on modern hydrographic charts of a water depth approaching 1000 fathoms within this distance, irrespective of the bearing (see fig. 2). According to the presently accepted surveys Ross's deep sounding seems to have been in a depth of 500–600 fathoms, though the 450 fathoms sounding close inshore may well have been reasonably accurate.



te IV. *Gorgonocephalus arcticus* Leach, 1819. B.M. (N.H.) registration No. 1953.4.8.110. This is obably the specimen brought up on Ross's sounding line, but the available documentation is not ficient to place this point beyond doubt.[35]

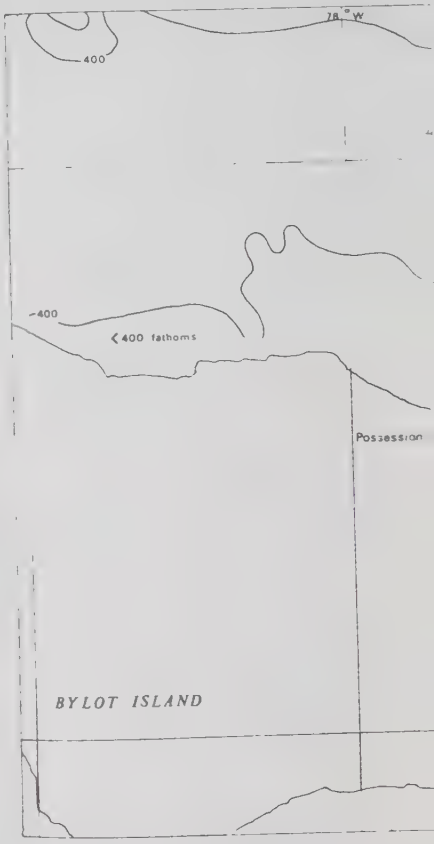


Figure 2. Detail of the area where Ross t
1,000 fathoms. The closed circle indicates
bearing from Possession Bay, and the open
the same sounding.
The depth contours in this chart and in F
soundings on Canadian charts 7220, 7052
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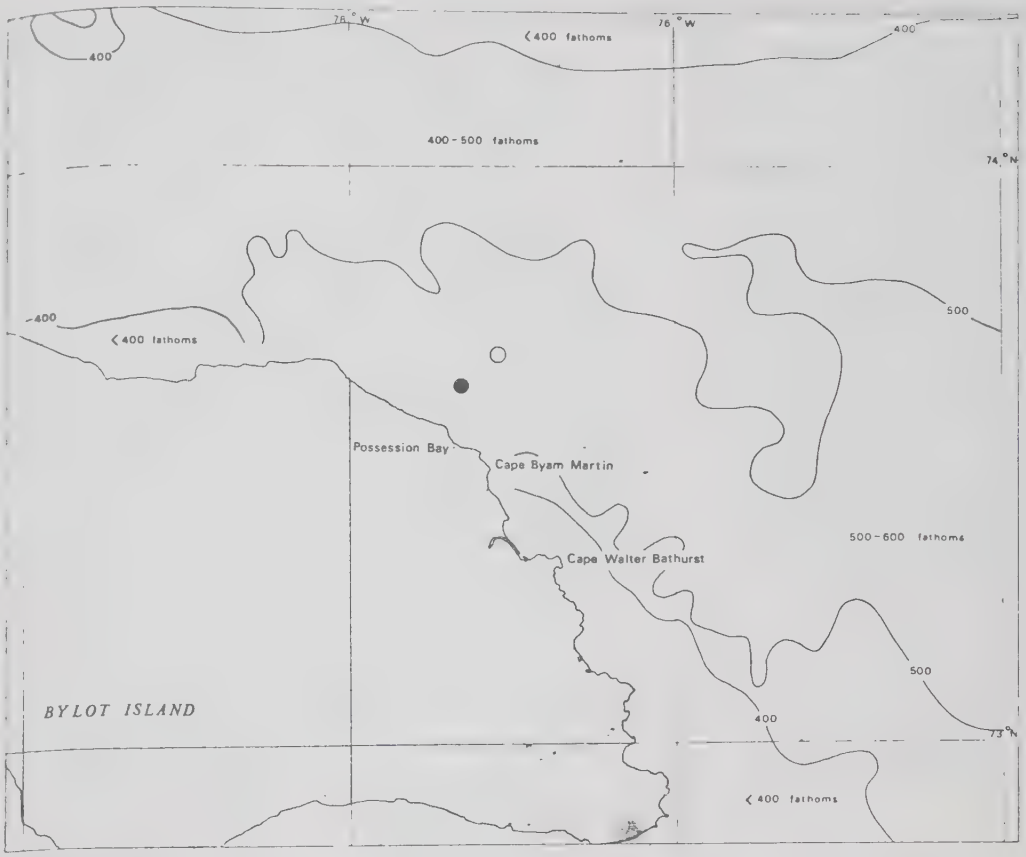

Figure 2. Detail of the area where Ross took his deep sounding on 1 September, 1818, supposedly in 1,000 fathoms. The closed circle indicates the site of the sounding according to the distance and bearing from Possession Bay, and the open circle marks the latitude and longitude given by Ross for the same sounding.

The depth contours in this chart and in Figs. 3 and 4 are in fathoms. They are drawn from the soundings on Canadian charts 7220, 7052 and 7054, and are reproduced by permission of the Canadian Hydropgraphic Service. Although these are the best available charts, detailed hydrographic surveys have not yet been carried out in this area and the contour positions cannot therefore by considered as accurate.

If this assessment is correct, how can such a discrepancy be explained? Ross says that they could not detect any appreciable surface current causing the ship to drift and this may well have been so. But since the entanglement of the starfish in the line proves that a considerable length of it must have been lying on the sea-bed, the most likely explanation is that a bight of the line was carried away from the ship by a fairly strong subsurface current, probably close to the bottom.

The uncritical acceptance of this sounding in the late 1860's by Carpenter and Wyville Thomson and, through them, of the oceanographic world at large, was mainly due to the influence of Sabine's "recollection" of it. The entry in Sabine's journal for 1 September runs to 2½ foolscap sheets, the bulk of which is devoted to an account of the shore excursion referred to in all the other documents; but he ends the entry with a short reference to the sounding.

"Whilst we were on shore the ship sounded in 1000 fathoms muddy bottom being between one and two[37] miles offshore – A magnificient Asterias Caput Medusae was entangled by the line and brought up with very little damage. The mud was very soft and of a greenish colour and contained small specimens of Lumbricus tubicola".

Fifty years later Sabine had quite deservedly won the respect of the scientific community through a long and distinguished career. It was quite natural, therefore, that Carpenter and Wyville Thomson should discuss these early oceanographic results with him when they were themselves embarking on the historic series of cruises on the *Lightning* and the *Porcupine* which ultimately led to the *Challenger* expedition itself. In a footnote to the summary of the results of the first cruises of the *Lightning,* Carpenter[38] refers to such a discussion with Sabine, beginning with the above extract from his journal but with the notable omission of the first five words. Sabine continues "So far my written journal, but I can add, from a very distinct recollection, that the heavy deep-sea weight had sunk, drawing the line with it, *several feet* into the very soft greenish mud, which still adhered to the line when brought to the surface of the water. The starfish had been entangled in the line so little above the mud, that fragments of its arms, which had been broken off in the ascent of the line, were picked out from amongst the mud". This quotation was subsequently repeated in Wyville Thomson's classic *Depths of the Sea,*[34] and in the historical introduction to the summary of the *Challenger* expedition results.[39]

Considering Sabine's eminence in the late 1860's it is perhaps not surprising that this account should have been accepted at its face value, despite the fact that he was by now almost 80 and was recollecting an event which had taken place half a century earlier. However, as we have seen, on the afternoon in question Sabine was on shore and did not return to the *Isabella* until well after the sounding had been taken, so that his "very distinct recollection" was at best a secondhand one derived from the officers who had remained on board. It would be wrong and unjustifiable to suggest that Sabine was deliberately overstating his memories, indeed he could have had no possible reason for doing so. But it is interesting to reflect on the credence that is often attributed to the words of eminent sages even when they pontificate on matters other than those for which they achieved greatness!

Before leaving this first deep sounding it is worth examining Ross's reference to the temperature measurements carried out at the same time, since these raise some points which are important in the interpretation of the later soundings.

Ross was expected to take surface and sub-surface temperatures for two main reasons. First there was the general aim of improving the very inadequate knowledge of Arctic hydrography and, secondly, water temperature along with specific gravity determinations were expected to identify currents flowing through the northwest passage or from the Arctic Ocean.

To measure the sub-surface temperatures the *Isabella* and *Alexander* were each provided with a Six self-registering thermometer in which the maximum and minimum temperatures were recorded by small indices pushed around a U-shaped tube by a column of mercury. As Ross mentions in his 1 September entry quoted above, the *Isabella's* instrument was broken early on in the voyage, an event recorded in the Meteorological Journal for 13 May.

"The self-registering thermometer sent down to 180 fathoms on coming up that part of the glass tube which contains the spirit was found to be broken just at the bend".

Sabine also records this breaka
that I have one of my own to sub
this "substitute" freely available t
Sabine ashore, the Captain had to
32° at 80 fathoms to which he re
Sir Humphry Davy. This bottle w
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Ross ends his account of the h
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seems likely that Ross was referri
in Parry's personal journal[41].

"Sent the register thermometer
30°, water at the surface 36½ –

Ross seems, then, to have beer
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description of the next deep sou

SOUNDING 2

The second deep sounding was ta
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Bylot Island and Baffin Island.
72°22′52″N; 73°06′30″W, with

"At six p.m., it being quite ca
clamms, and found one thousand
ever reached in Baffin's Bay. As
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sand. Although this mud was o
we had before obtained, it was
organic remains; but a small sta
marking eight hundred fathoms.
the whole distance. When at fi
per second, and when near one
per fathom."

Sabine also records this breakage in his journal, but he adds "It happens fortunately that I have one of my own to substitute". He does not, however, seem to have made this "substitute" freely available to Ross, and on the afternoon of 1 September, with Sabine ashore, the Captain had to employ other means to record the temperature of 32° at 80 fathoms to which he refers. This would have been the water bottle invented by Sir Humphry Davy. This bottle was fitted with a stop-cock ingeniously opened and closed by a pressure-operated piston which could be adjusted to act at any depth between 5 and 80 fathoms[40]. Although the stop-cock leaked and the instrument's use was limited to fairly shallow depths, Ross frequently measured the temperature of the water which it brought to the surface to obtain some idea of the sub-surface temperature in the absence of the self-registering thermometer.

Ross ends his account of the hydrographic observations of 1 September with a reference to the determination of the temperature at a depth of 250 fathoms from the *Alexander,* whose self-registering thermometer was still intact. There is, however, no mention of this determination in any of the *Alexander's* documents for that day and it seems likely that Ross was referring to a measurement made on 6 September and recorded in Parry's personal journal[41].

"Sent the register thermometer down to 246 fathoms – no bottom. Temp. indicated 30°, water at the surface 36½ – Air 41°"

Ross seems, then, to have been quite capable of transposing the events of one day to his account of another and this may help to explain some of the inconsistencies in the description of the next deep sounding.

SOUNDING 2

The second deep sounding was taken five days later, on 6 September, when the ships were some 50 miles further to the south-east, off the opening of Pond Inlet between Bylot Island and Baffin Island. In his narrative Ross gives the position of this sounding as 72°22′52″N; 73°06′30″W, with Cape Coutts bearing SW by S 21 miles.

"At six p.m., it being quite calm, and the water smooth, we sounded with the deep sea clamms, and found one thousand and fifty fathoms, which were the deepest soundings we ever reached in Baffin's Bay. As we had only one hundred and twenty fathoms fifteen miles further north, it is evident, the bottom of the sea, like the land, must here be very mountainous. The mud at the bottom was so extremely soft, that the instrument sunk completely into it, and considerable force was required to draw it out. The sea being a dead calm, the line became perfectly perpendicular, and we had a good opportunity of obtaining the exact depth before it started out of the ground. The instrument came up completely full, containing about six pounds of mud, mixed with a few stones and some sand. Although this mud was of a substance to appearance much coarser than that which we had before obtained, it was also of a much looser nature, and had in it no insects or organic remains; but a small starfish was found attached to the line below the point marking eight hundred fathoms. The instrument took twenty seven minutes to descend the whole distance. When at five hundred fathoms it descended at the rate of one fathom per second, and when near one thousand fathoms down, it took one second and a half per fathom."

So far this account agrees almost word for word with the manuscript Meteorological journal, but in his published version Ross adds a further section which has no counterpart in the manuscript.

"Although the check the instrument made to the motion of the line when it struck the bottom was evident to all, I wished to put the fact beyond doubt; and for this purpose, I set the instrument so nicely that the least resistance at the bottom would make it act, and having attached the self-registering thermometer to it, I let it down first to five hundred fathoms, and in the same manner to six hundred, seven hundred, eight hundred, and a thousand, in succession. At each time it came up empty, and the thermometer each time shewed a lower temperature, proving clearly that the water became colder as it became deeper, and also indicating that the instrument had *not* reached the bottom, even as far as the depth of one thousand and five fathoms. It occupied one hour for all hands to pull it up from that depth, and an account of the temperature of the sea will be found in the Appendix."

But in the relevant Appendix, the one in which the deep sea clamm is described, Ross attributed these temperature determinations to the following day, and at the same time refers to another source of sub-surface temperatures which he quite often made use of, the mud brought up from the sea-bed by the clamms.

"On 6 September, in latitude 72°23′N and longitude 73°07½′ west, we sounded in one thousand and fifty fathoms, from which depth the instrument brought up six pounds of very soft mud; the next day being quite calm, we tried the temperature of the sea at five, six, seven, eight hundred, and a thousand fathoms; and found its temperature decrease from thirty-five gradually to the same temperature as the instrument gave it, which was twenty-eight three-quarters."

In fact, as we shall see, there is good evidence that the serial temperatures were not measured on 7 September either, but Ross's account of the 6 September sounding contains other possible "mistakes" too.

His reference to the starfish in the line at 800 fathoms, for instance, is so similar to the account of the capture of the *Gorgonocephalus* in the first deep sounding that it could easily be the same event, and the absence of any reference to this second starfish in the zoological appendix tends to support this suggestion.[42]

The true depth of this second sounding was probably even less than that taken on 1 September, for a position 21 miles NW of Cape Coutts would be in water considerably shallower than 300 fathoms, and even 30 miles off the Cape the depth is little more than 400 fathoms (see fig. 3). The 1000 fathoms isobath does not approach closer to Cape Coutts than about 80 miles, and this in a due easterly direction! On the other hand, a position with Cape M'Culloch bearing SW 17 miles, the locality given for the "one hundred and twenty fathoms fifteen miles further north" referred to by Ross, would be over 300–500 fathoms of water. Ross's position fixing was obviously very faulty in this area and his deep sounding was very inaccurate indeed, despite his statement that they "had good opportunities of obtaining the exact depth . . . ". In this case, however, the personal journals of Robertson and Parry contain a clue to at least a partial explanation of the inaccuracy. For both manuscripts refer to the effects of a surface current on the course of the ships, Parry mentioning that they had been 'set' 17 miles during the previous 24 hours, while Robertson says that they had been pushed "much to the southward and eastward for the last 8 days", by a current running at an estimated half knot.

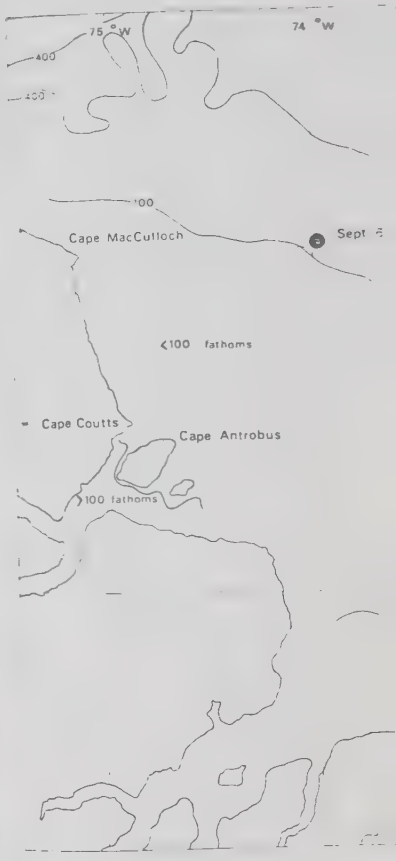

Figure 3. Ross's deep soundings of 6
As before, the closed circles mark th
while the open circles mark Ross's st

This current, presumably part o
carried the *Isabella* several hund
reach the sea-bed, making accur

SOUNDING 3

The following morning the ship
Cape Cargenholme bearing SSW
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rough log is short and somewha

"At 9 hove to, to sound ter
28¾° at 10 filled and made sail

On the left hand folio this s
apparent discrepancy is clarifie
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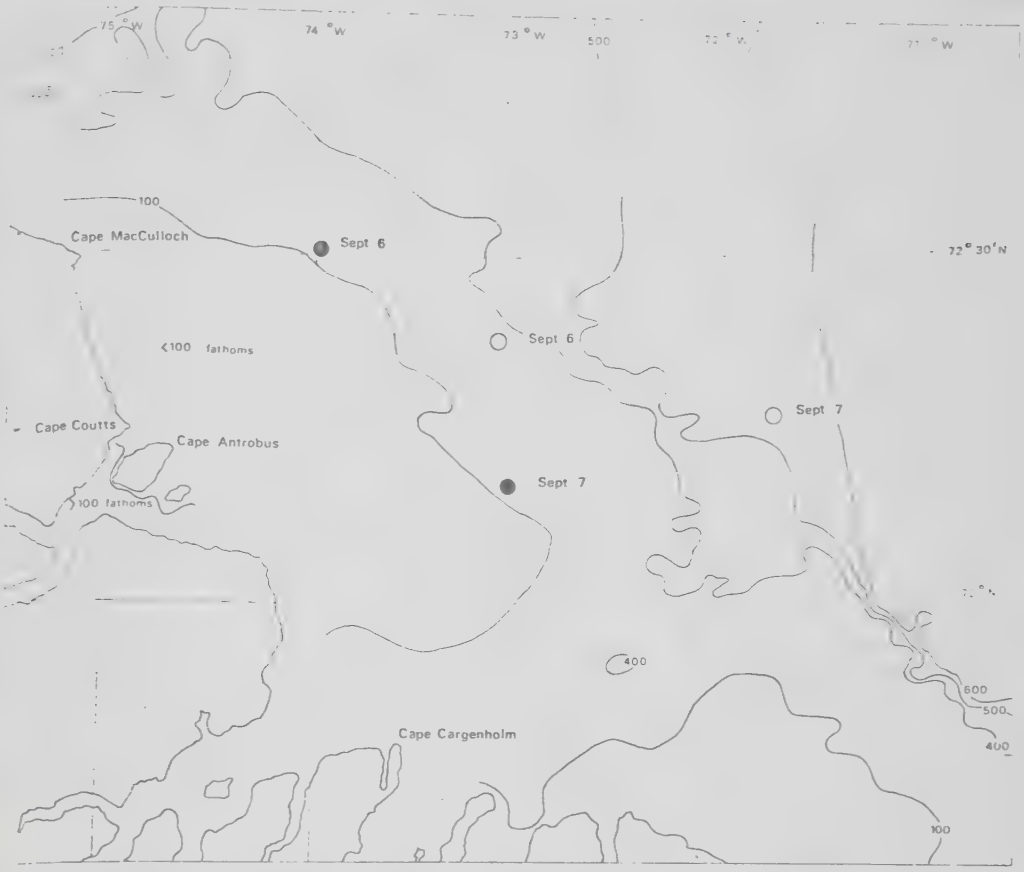

Figure 3. Ross's deep soundings of 6 September (1,050 fathoms) and 7 September (1,015 fathoms). As before, the closed circles mark the positions according to the distances and bearings from the land, while the open circles mark Ross's stated latitudes and longitudes.

This current, presumably part of what is now known as the Baffin Current[43], could have carried the *Isabella* several hundreds of yards during the half hour the clamms took to reach the sea-bed, making accurate sounding almost impossible.

SOUNDING 3

The following morning the ships were off Bergeson and Dexterity Islands[44]. Here, with Cape Cargenholme bearing SSW 24 miles they sounded for the third time in what they thought was more than 1000 fathoms of water. The entry recording the event in the rough log is short and somewhat unclear.

"At 9 hove to, to sound temperature of the sea at 1005 fathoms below the surface 28¾° at 10 filled and made sail."

On the left hand folio this sounding is given as 1015 fathoms soft mud, but the apparent discrepancy is clarified by Ross's entry in the Meteorological journal, though he starts by getting the time wrong!

"At 8.30 being quite calm, we sounded in 1015 fathoms and at the same time sent down the Self-Register thermometer to 1005 fathoms which showed the temperature to be 28¾ the line was directly perpendicular the weight weighed 100 pounds distinctly perceived to strike the bottom and was 21 minutes and 2 seconds in descending it was hauled up in 48 minutes, the lead appeared (like the Clamms) to have been more than its length sunk in the mud:– immediately after a breeze springing up from the SW by compass and all sail was made. The clouds soon obscured the land which had been seen at 5 leagues distances."

In his published narrative, however, Ross expands this passage and describes two separate soundings, the first using the deep-sea lead alone and the second using the clamms and the thermometer. Except for the omission of the reference to the self-registering thermometer and the temperature the account of the first sounding agrees closely with that quoted above; he then adds the following sentence (p. 194).

"After this experiment, the clamms were sent down, with a self-registering thermometer attached to it, to one thousand and five fathoms, and the temperature of the sea at the depth was ascertained to be twenty-eight and a half; the instrument coming up without anything in it, proved it had not been at the bottom."

This account of a second sounding is clearly not correct, for all of the manuscript sources, including Robertson's journal and Ross's Captain's log[45], agree that the *Isabella* was hove to for only one hour. This would be just sufficient for the times given by Ross himself for the descent and recovery of the lead on the first sounding, but neither the second lowering with the clamms nor the elaborate serial temperature measurements mentioned in the appendix (see above) could possibly have been accomplished in the time available.

In fact, there are so many inconsistencies between the various accounts of the soundings of 6 and 7 September that it is difficult to know which, if any, of the statements are completely reliable. But while the soundings on neither day approached 1000 fathoms, that obtained on the 7 September was probably a great deal deeper than the earlier one. For although the stated bearing and distance from Cape Cargenholme would put this sounding, according to modern surveys, in water little more than 100 fathoms deep, the ship would have had to be only a few miles further to the north-east to be over 600 fathoms or more (see fig. 3).

SOUNDING 4

During the next two weeks the ships continued to move generally towards the south-east. Apart from a few relatively shallow soundings, little oceanographic information was obtained until 18 September, when they were in Davis Strait once more, off the Cumberland Peninsula. Here they obtained what was thought to be the deepest sounding of all.

"At sun-set we hove to, as usual, to sound, and give the *Alexander* an opportunity of joining; and we found bottom at the great depth of one thousand and seventy fathoms, and obtained a quantity of very soft mud of a rusty colour".[46]

In the rough log this sounding receives only the following brief mention, "7.30 p.m. hove to to sound", and in the soundings column opposite 9.30 "1070 Reddish mud."

The Meteorological Journal is similarly terse.

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SUB-SURFACE TEMPERATURE MEA

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2 above). But, as we have seen,

"We sounded at 8 p.m. in 1070 fathoms which is the deepest water we have yet had, got from the bottom some very soft rusty coloured mud . . ."

The position of this final deep sounding is particularly difficult to establish, for in addition to the problems already mentioned there is some confusion about the names of the headlands seen in this area.

In the table published with his narrative Ross states that the sounding was taken at a point from which Cape Searle bore SW 9 miles. But they had discovered and named Cape Searle on the previous day and, according to the narrative, had sailed beyond this headland during 18 September, identified Dyer's Cape and established its latitude as 66°42′N (see fig. 4). Ross's short account of the sounding, quoted above, follows immediately after his statement that they had "explored the coast as far as latitude 66°50′", that is only 8′ of latitude north of Cape Dyer, which suggests that the sounding was made off this cape and not off Cape Searle. Ross's error is explicable if, as seems likely, he based the information given in the table of soundings on Bushman's manuscript chart (see note 21), for here the names of Cape Searle and Cape Dyer are transposed!

As in the previous cases no reliance can be placed on Ross's stated latitude and longitude for this sounding – 67°27′6″N; 61°09′W. As it happens, this position corresponds to a sounding of over 1000 fathoms on modern charts (see fig. 4), but since this locality is some 30 miles from the nearest land, instead of the 9 miles given by Ross, his figures must be wildly inaccurate.

The most likely position for the sounding therefore seems to be a few miles, certainly not more than 10 or 15, off Cape Dyer. But whether it was taken here or off Cape Searle it was definitely not in 1070 fathoms of water, for apart from the 1000 fathom sounding referred to above and two further isolated soundings a little over 500 fathoms, some 27 miles offshore, the 500 fathoms isobath does not approach closer than about 40 miles from the coast anywhere in this region (fig. 4).

SUB-SURFACE TEMPERATURE MEASUREMENT

Ross's attempts to follow his instructions "to measure the temperature of the sea at various depths", have already been briefly referred to. Several dozen such determinations were made during the polar voyage, using the deep-sea clamms, Davy's water bottle and the self-registering thermometers. Most of the measurements were made at only one depth at each locality for comparison with the temperature records of the surface water and of the air which were also routinely taken. This was not a new departure, for many sub-surface temperature measurements had been taken on earlier voyages, particularly after the introduction of a suitable form of Six's self-registering thermometer in 1798[47]. But the 1818 expedition probably saw the first attempt to measure the temperature at a series of different depths at the same place, a practice which together with simultaneous salinity determinations was to become one of the main tools of the physical oceanographer.

The first such serial temperature determination was considered by Wyville Thomson[48] to have been that described by Ross in his Narrative for 6 September 1818 (see Sounding 2 above). But, as we have seen, there is good reason to believe that Ross's account was

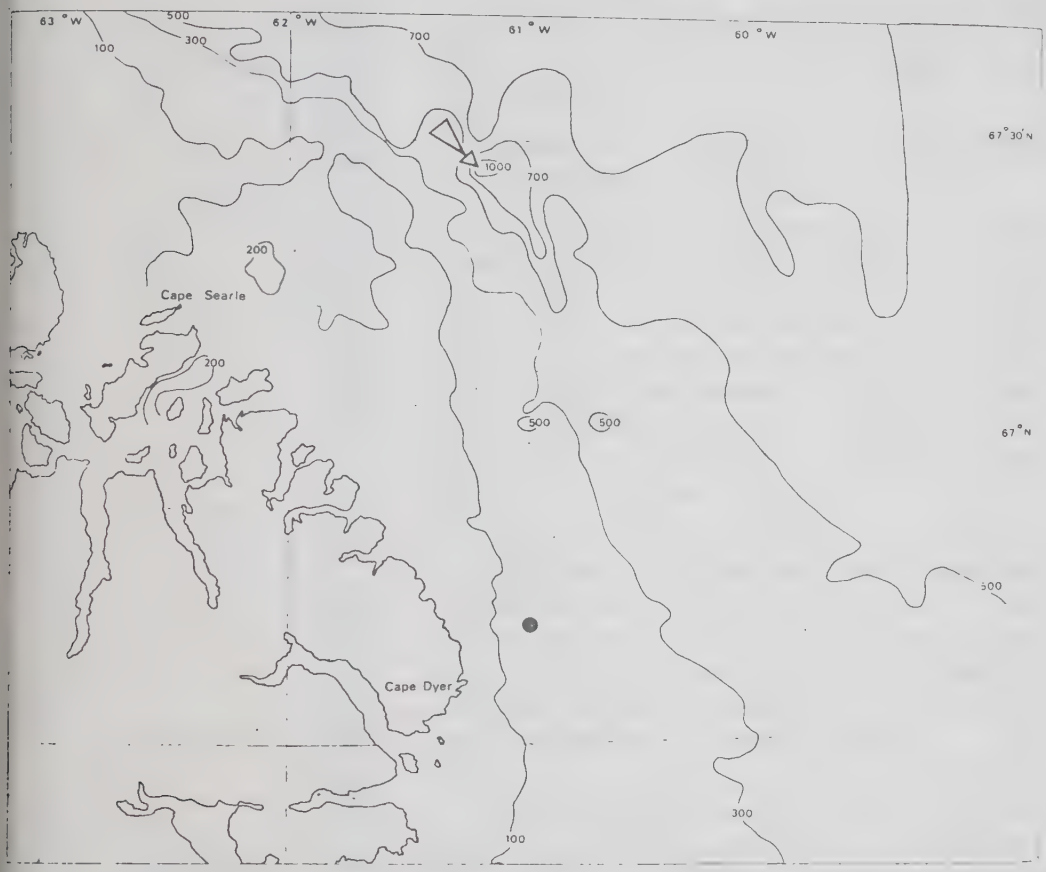

Figure 4. Ross's sounding of September 18th, 1818, supposedly in 1,070 fathoms, was probably taken off Cape Dyer (see text). Ross's latitude and longitude for this sounding, marked by the arrow, corresponds to a modern sounding of 1,025 fathoms, but it is some 30 miles offshore instead of the 9 miles which Ross mentions.

based on either a faulty memory or a vivid imagination and that no such data were obtained at this time. On 19 September however, when the ship was off Dyer's Cape, a series of temperature measurements at different depths were certainly made from the *Isabella* and were described by Ross as follows.

"In the afternoon it fell quite calm, when we sounded in six hundred and eighty fathoms; I thought it a good opportunity to try the temperature at different depths by means of the self-registering thermometer, and it was found to be as follows: at six hundred and sixty fathoms, 25½°; at four hundred, 28°; at two hundred, 29°; at one hundred, 30°. The bottom was of a yellowish rusty colour, and very soft."

This account agrees very closely with the manuscript remarks in the Meteorological Journal, except here he says that at 400 fathoms the temperature was 29°. It also agrees with the figures quoted by Alexander Marcet in his classic summary paper on the temperature and specific gravity of sea waters which also includes observations made from the *Alexander*, the *Dorothea*, and the *Trent*[49]. Marcet attributes the *Isabella's* temperature measurements to Sabine whose private journal refers to a slightly greater total depth and a slightly higher minimum temperature than in Ross's version.

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"Having sounded in 750 fm the Registring[sic] thermometer was sent down to 680 fm and on coming up the Index of greatest cold was 25¾° – never having known it lower than 28° in former instances, even at a depth of 1000 fm and at other times when close to the bottom . . .".

This extremely low reading obviously intrigued Sabine and he was anxious to convince his readers of its accuracy, for he continues.

". . . I was very careful in examining the thermometer, but could discover no other reason for it than the actual coldness of the water; Capt. Ross and I were both on the spot to receive the tin case in which the thermometer is sent down; it was full of water and on drawing out the thermometer Capt. Ross remarked that the mercury was close to the Index; it fell instantly and rapidly, but I have the same belief that at the moment when my eye first glanced on it, it was close up – unfortunately the water had been emptied out of the tin case before I could ask for it. The index was reset and the thermometer sent down severally to 400, 200 and 100 fm the temperature being 29° at the first two depths, and 30° at the last".

But apart from his interest in the 25¾° reading as a record "low", there is no indication that Sabine or anyone else aboard the *Isabella* or *Alexander* was aware of the wider significance of these results. For the low bottom temperatures and the consistent indications from almost all the temperature determinations that Baffins Bay became colder with increasing depth were completely at variance with the so-called "4° theory" of oceanic temperature distribution that was widely adopted during the middle decades of the nineteenth century.

This theory was founded on the knowledge that fresh-water has a maximum density at 4°C (39°F) and is lighter at both higher and lower temperatures. On the assumption that sea-water behaved in the same manner it was confidently predicted that the great ocean depths would be filled with a heavy mass of water at this temperature of maximum density. In low latitudes this water mass would be overlaid by warmer layers, so that in these areas the sea would generally become colder with increasing depth – a state of affairs for which there was abundant evidence. At around 50–60° both north and south of the equator, where the mean air temperatures hover around the 4°C mark, the sea was expected to assume this temperature from surface to bottom, while in higher latitudes colder but lighter water would be produced at the surface, so that in the Polar regions the sea was expected to become warmer with increasing depth.

The temperature measurements made from the *Dorothea* and the *Trent* on the eastern expedition in 1818 seemed to support this theory, for they showed that the sea to the east of Greenland generally did become warmer towards the bottom. But when Marcet examined these results, together with those obtained by the *Isabella* and *Alexander* and the water samples collected on both voyages, he realised that this temperature inversion was caused by the overriding effect of salinity stratification on the water density. He carried out careful laboratory experiments and satisfied himself that, unlike fresh water, salt water continues to become heavier with decreasing temperature until it freezes.

But Marcet's results were disregarded in favour of observations which supported the more traditional view – and there was a good deal of such support. James Clark Ross, for instance, apparently encountered the "circle of mean temperature" on his way to the Antarctic in the *Erebus* and *Terror* in 1839 when he found a uniform 4°C from surface to bottom at about 56°S. It was later realised that these results, and others like them,

were obtained because thermometers unprotected against the effects of pressure were used, so that as the instruments were lowered into the sea the bulbs were squeezed by the weight of water and the mercury was forced up the thermometer stem to give artificially high readings. From the late 1850's onwards sub-surface temperatures were generally taken with thermometers in which the bulbs were protected either by thickened glass or by enclosing them in a second bulb part filled with alcohol[50]. But despite the resulting accumulation of contrary evidence, the 4° theory continued to be favoured and was even accepted by Wyville Thomson and Carpenter until they also recorded temperatures incompatible with it during the cruise of the *Lightning* in 1868. In his summary of the *Lightning* results and of the even more significant ones obtained by the *Porcupine* in 1869 and 1870 Wyville Thomson reviewed the history of deep-sea temperature measurements and realised the significance of the data collected during Ross's expedition[51]

Wyville Thomson and subsequent reviewers have assumed that in order to record the low temperature that they did, the thermometers employed during the 1818 voyage must have been pressure protected in some way, albeit unintentionally. One possibility is that this protection was afforded by the tin case in which the instruments were sent down[52]; there is some support for this in Sabine's reference, in the passage cited above, to the case reaching the surface full of water on September 19th – as though this was not usually so. But even if the case normally protected the thermometer it had obviously failed to do so on this occasion, so that the true temperature at the lower end of the series would have been even less than the one recorded. This seems highly unlikely for even 25½° or 25¾°F would be unusually cold for this region.

Unfortunately, no details of the construction of the thermometers or of their cases are available, so that it is not possible to pursue this point any further. But whether the instruments were protected or not, Sabine's statement that the mercury was close to the index when it arrived at the surface is suspect, for it is difficult to believe that the thermometer, even with its insulating layer of water inside the tin case, could have been hauled through over 400 fathoms at a temperature at least 3°F higher than that recorded at the greatest depth reached without any effect on the mercury. This is a small and unimportant point, but it does suggest that the normally very careful eyes of Sabine might have been susceptible to "seeing" what his mind thought or hoped he should see rather than the actual situation, and casts at least some doubt on the accuracy of the temperature records.

There is also the question of the reliability of the instruments themselves. Even fifty years later the carefully made self-registering thermometers used aboard the *Challenger* had to be handled with great care, for any sudden jolt was likely to move the indices and produce erroneous readings. The much earlier thermometers used by Ross are hardly likely to have been free from this same susceptibility to rough handling, and the instrument on the *Alexander* was definitely unreliable. In this case, however, the problem seems to have been overtight indices rather than loose ones, for in his private journal for 4 September, 1818, Parry says that when his thermometer was sent down to 230 fathoms ". . . the index did not move up, and was surrounded by the mercury when it came in", a fault which had been noticed before when the instrument had not been used for some time[31].

These uncertainties, coupled with the doubtful nature of the soundings generally, make Ross's sub-surface temperatures unacceptable at their face value. Despite their

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unreliability in detail, however, they do show consistent trends. Repeatedly the temperatures obtained with the clamms, Davy's water bottle and the self-registering thermometers showed that the temperature decreased with increasing depth, even when the surface layers were well below 4°C (39°F), and this should have made adherents of the 4° theory scrutinize their basic assumptions about the physical properties of sea water.

CONCLUSION

Having examined these events of the summer of 1818 in somewhat pedantic detail it is clear that the place in oceanographic history usually attributed to John Ross and the voyage of the *Isabella* and the *Alexander* must be reviewed.

Ross certainly cannot be credited with having obtained the first bottom sample from a depth of 1000 fathoms nor, as a consequence of this, with the first demonstration of the existence of life at this depth. His deepest soundings, at least amongst those in which the line reached the bottom, were in no more than 500–600 fathoms of water, and it was probably from this sort of depth that the *Gorgonocephalus* was obtained. Nevertheless, even this was almost double the limit for life suggested by Edward Forbes and tenaciously believed in by many of the supporters of his azoic theory, so that Ross should undoubtedly be credited with this 'first'.

Similarly, he was obviously an enthusiastic and talented innovator, for in addition to the deep-sea clamms he also designed the "Hydrophorus", an ingenious device for obtaining water samples from depths greater than the 80 fathom limit of Sir Humphrey Davy's water bottle.[53] There is no evidence that the hydrophorus progressed beyond the drawing board, and the *Hecla* and *Griper* were supplied with a water sampler designed by Marcet for the 1819–1820 voyage, though Parry was provided with the deep-sea clamm and used it with considerable success. This seems to have been the last time the instrument was regularly employed and it probably ended its days abandonned and forgotten in an Admiralty store, but it was probably an important inspiration in the design of subsequent samplers making use of the forceps principal. For the next successful instrument based on this technique seems to have been the "Bulldog clam" developed during McClintock's survey of the North Atlantic in 1860.[54] The naturalist during this voyage, G. C. Wallich, was certainly familiar with Ross's work and was undoubtedly involved in the design of the new instrument. The two halves of the Bulldog clam were closed by a strong rubber band, instead of by a weight sliding down inclined planes, and there was also a mechanism for detaching the weights on the sea bed before the sampler was brought up, but the "clam" idea seems to have been taken directly from Ross's sampler. Ross should therefore, perhaps, be credited with having produced the prototype of all the modern oceanographic grabs in use today.

Ross was also an avid collector of data and it was certainly largely due to his enthusiasm that, despite the failure to accomplish the main purpose, the voyage of the *Isabella* and *Alexander* was more productive of oceanographic information than any of the numerous other naval expeditions to the arctic during the subsequent decade. Unfortunately, as we have seen, this enthusiasm seems to have been marred by a carelessness in reporting and assessing his observations which seriously detracts from their value.

Parry, on the other hand, had a much more critical attitude towards the scientific results which he obtained and this may have discouraged him from making as many oceanographic observations as he might otherwise have done.[55] In his published narrative

of the voyage of the *Hecla* and *Griper,* for instance, he reports a sounding on 2 May, 1819, of 1050 fathoms ". . . by the line", but continues by expressing grave doubts about the accuracy of his sounding technique.

". . . I believe the depth of water did not exceed eight or nine hundred fathoms, the ship's drift being considerable on account of the swell. It should be remembered, also, that where the soundings exceed five or six hundred fathoms, even in very calm weather, the actual depth must in the usual way of obtaining it, be a matter of some uncertainty, for the weight of the line causes it to run out with a velocity not perceptibly diminished, long after the lead or the clamms have struck the ground."[56]

On his chart Parry plots this sounding in a position off the mouth of Lancaster Sound at about 74°30′N: 78°W, where the true depth seems to be a good deal less even than the 800–900 fathoms he was willing to accept. But at least he was aware of the pitfalls inherent in taking deep-sea soundings, and particularly of the problem of detecting the arrival of the weight on the sea-bed. As mentioned above, this difficulty was largely overcome by the practice of accurately timing the passage of each section of the sounding line, apparently introduced by James Clark Ross in the late 1830's and used with reasonable success up to the time of the *Challenger* and beyond.

But in 1818 John Ross seems to have been blissfully unaware of these possible reasons to doubt the accuracy of his soundings. Or perhaps he was so aware of the scepticism with which his account of the voyage would be received in some quarters that he silenced any doubts about the veracity of the scientific results which he might have had in his own mind so as not to provide his critics with more ammunition than necessary!

He need not have worried, for so many other issues assumed much greater importance in the minds of John Barrow and the other commentators that they either ignored the scientific results completely or passed over them in a very cursory manner. Half a century later the sounding results and the sub-surface temperature measurements were resurrected and have been uncritically accepted ever since. Now, 100 years further on, it seems that Ross's results are totally unreliable and in a positive sense have no real place in oceanographic history.

But to relegate the voyage of the *Isabella* and the *Alexander* in this way would be to lose sight of the lesson to be learnt from it. For by the time Wyville Thomson quoted Ross's figures in his *Depths of the Sea* in 1873 the fact that they were erroneous had no significance as they had long since been superseded by later work. The important point is that they had been largely disregarded during the intervening period, for while a critical examination and an attempt to check them during the 1820's and 1830's would have revealed Ross's shortcomings much sooner, the progress of Oceanography might have been advanced by several decades.

ACKNOWLEDGEMENTS

I am grateful to the staffs of the Public Record Office, the Scott Polar Research Institute, the Admiralty Hydrographic Office, the Royal Society and the Plymouth Public Library for allowing me to consult and quote from documents in their care, and particularly to Miss M. J. Perry, Lt Cdr A. C. F. David and Dr Alan Cooke for their assistance during my visits to their institutions. My thanks are also due to Miss Ann Gurney for drawing the charts, to Mr C. B. Keats for taking the photographs and finally to my wife for tolerating Sir John Ross's domination of our lives for so long.

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1 Since all of Ross's references to d
or about 1·83m.

2 Deacon, M. 1971. *Scientists and*

3 See, for instance, the following w
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London, pp. 240.
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9 Jones, *op. cit.* p. 300.

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13 Ross, *op. cit.* p. 11.

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a lighter clamm which might be used b
that this version was ever completed.

18 Ross's published narrative, Appe

19 Ross. J. C. 1847. *A voyage of*
Murray, London, 2 vols.

20 Gould, R. T. 1924. The Ross d
of about 2200 fathoms, although Ross
the check and recorded a sounding of

21 Admiralty Hydrographic Office,

22 Parry, A. *op. cit.* p. 69.

23 Hydrographic Office, d 52 A i

24 The first edition of this work,
four months after Ross had returned t
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the inconsistencies, but it differs fr
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1 Since all of Ross's references to depth are in fathoms this unit is used here. 1 fathom = 6 feet or about 1·83m.

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17 The entry for 28 September, 1818, in Ross's manuscript Meteorological Journal and Sea Log (Public Record Office, ADM 55/82) mentions the armourer being employed "forging the iron work of a lighter clamm which might be used by the watch in shoaler water". There is, however, no evidence that this version was ever completed.

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19 Ross. J. C. 1847. *A voyage of discovery and research in the Southern and Antarctic Regions.* Murray, London, 2 vols.

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22 Parry, A. *op. cit.* p. 69.

23 Hydrographic Office, d 52 A i 2 and E 311 A i 1.

24 The first edition of this work, quoted from in this paper, appeared in March 1819, less than four months after Ross had returned to London, so that it is not surprising to find that he gets his dates mixed up and contradicts himself from time to time. The second edition, published in the following June after the controversy between Ross and Sabine had become public, still carried many of the inconsistencies, but it differs from the first in several details, including the almost total deletion of any reverence to Sabine by name!

25 Public Record Office, ADM 55/82.

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27 Robertson's journal is bound together with Ross' Meteorological Journal and Sea Log (see 17 above).

[28] Two slightly different versions of Sabine's journal are respectively in the libraries of the Royal Society and the City of Plymouth; the quotations used here are from the first of these.

[29] Fischer, A. 1819. *Journal of a voyage of discovery, to the Arctic regions, performed between the 4th of April and the 18th of November, 1818, in His Majesty's Ship Alexander.* London. pp. 104.

[30] Public Record Office, ADM 55/155.

[31] Public Record Office, ADM 55/3.

[32] Scott Polar Research Institute, Cambridge.

[33] There is no indication when or by whom these pages were removed, but their contents would obviously be of great interest in any re-assessment of what Ross did or did not see in Lancaster Sound

[34] Wyville Thomson, C. 1873. *The Depths of the Sea.* Macmillan, London, pp. 527.

[35] An earlier attempt to locate Leach's type is referred to by P. M. Duncan and W. P. Sladen in their *Memoir on the Echinodermata of the Arctic Sea to the West of Greenland,* London, 1882, pp. 82 (page 71).
"Careful and thorough search was then made for Leach's type specimen of *Gorgonocephalus arcticus* (obtained by Sir John Ross), which was deposited in the British Museum . . . Unfortunately it is impossible to say with certainty that the object of our quest was found. An old dried specimen, however, is still existant which is *supposed* to be Leach's type, and which, from its fragile nature, has never been moved since it was originally set out *by him.* This is at least the traditional(!) representative of *Gorgonocephalus arcticus;* for it is without ticket of any kind."
This state of affairs apparently persisted, for when the specimen illustrated here, which is assumed to be the one referred to by Duncan and Sladen, was finally registered in 1953 it was still "without ticket of any kind"!

[36] This point was noted in 1862 by G. C. Wallich in his detailed argument in favour of the existence of life at great depths, supported by his own soundings made from HMS *Bulldog* in 1860 (*The North-Atlantic Sea-Bed: comprising a diary of the voyage on board HMS Bulldog, in 1860; and observations on the presence of animal life, and the formation and nature of organic deposits, at great depths in the ocean,* London, pp. 160). However, Wallich does not use the capture of *Gorgonocephalus* as evidence that Ross's sounding was inaccurate, but seems rather to suggest that the starfish was dead when collected.

[37] In the Plymouth Public Library copy of Sabine's journal these numbers are crossed out and the figures 4 and 5 inserted.

[38] Carpenter, W. B. 1868. Preliminary report of dredging operations in the seas to the north of the British Islands, carried out in HMS *Lightning,* by Dr Carpenter and Dr Wyville Thomson, Professor of Natural History in Queen's College, Belfast. *Proc.R.Soc.* 17: 168–200, p. 186.

[39] Murray, J. 1895. A summary of the scientific results, in *Report on the scientfic results of the voyage of HMS Challenger during . . . 1873–76 . . . prepared under the superintendence of Sir C. W. Thomson (and . . . of J. Murray),* &c. 40 vol. in 50. London, Edinburgh and Dublin, 1880–95.

[40] Davy, H. 1818. Description of the apparatus, alluded to in the foregoing paper, for bringing up water from certain depths in the sea. *J.Sci.Arts, Lond.* 5: 231–233.

[41] Public Record Office, ADM 55/3.

[42] However, the *Gorgonocephalus* itself did not make its appearance in the appendix until the second edition of the narrative was published and then only amongst the new species described by William Elford Leach (see also fig. 1).

[43] See Muench, R. D. 1971. The physical oceanography of the northern Baffin Bay Region. Baffin Bay north water project. Scientific Report No. 1. Arctic Institute of North America.

[44] Ross called the islands Bell Isle and Marianne Isle.

[45] Public Record Office, ADM 55/81.

[46] Ross, published narrative, p. 210.

[47] Deacon, *op. cit.*

[48] Wyville Thomson, *op. cit.* p. 300.

[49] Marcet, A. 1819. On the specific gravity, and the temperature of sea waters, in different parts of the ocean, and in particular seas; with some account of their saline contents. *Phil.Trans.R.Soc.* 109: 161–208.

[50] See, for instance, Matthus, W. 1 for the determination of depth-tempera

[51] Wyville Thomson, *op. cit.* p. 30

[52] Wyville Thomson, *op. cit.* p. 30

[53] Ross was also far ahead of mos of steam power, though he had little e from 1829–33 (see Jones, 1972, *op. c*

[54] McClintock, F. L. 1861. *Rema* London, pp. 12.

[55] Deacon, *op. cit.* p. 231.

[56] Parry, W. E. 1821. Journal of Atlantic to the Pacific; performed in t Murray, London, pp. 310 (p. 30).

50 See, for instance, Matthus, W. 1968. The historical development of methods and instruments for the determination of depth-temperatures in the sea *in situ*. *Congr.int.Hist.Océanogr.* **1**. 35–47.

51 Wyville Thomson, *op. cit.* p. 300.

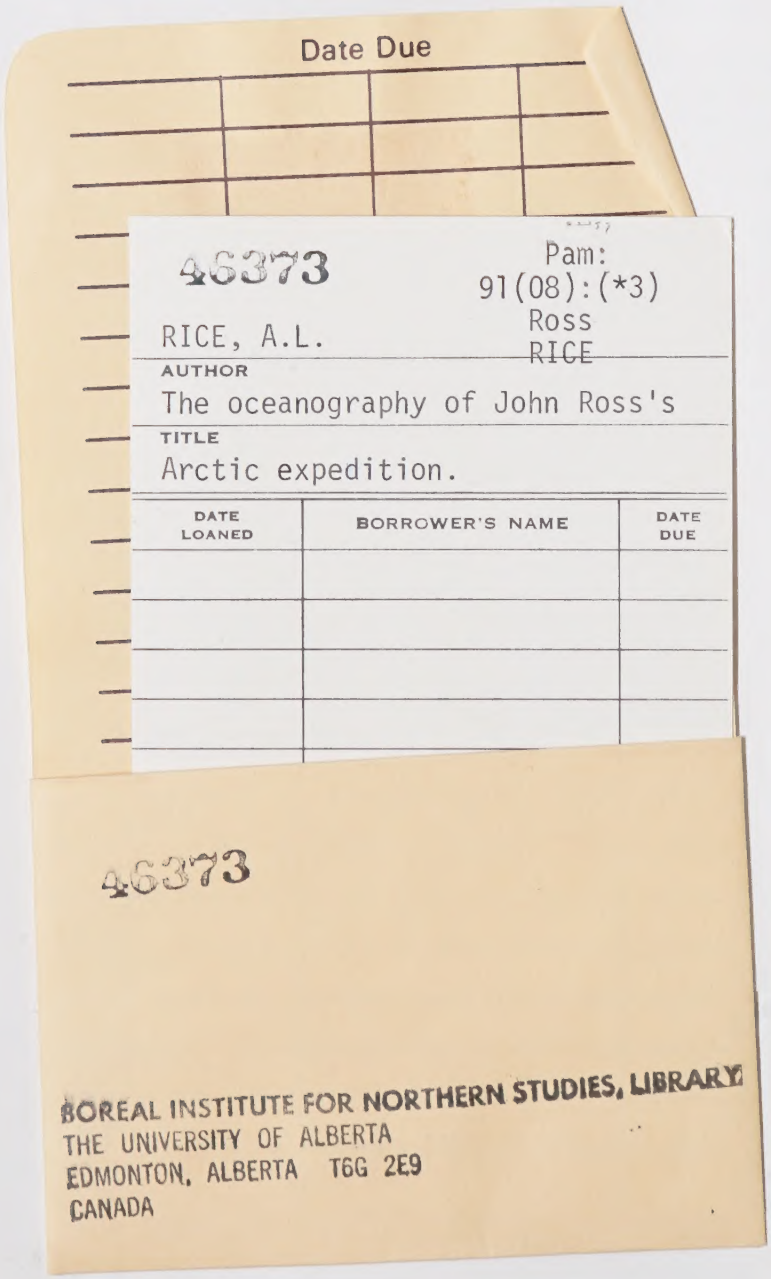
52 Wyville Thomson, *op. cit.* p. 301; Deacon, *op. cit.* p. 229.

53 Ross was also far ahead of most of his naval colleagues in his appreciation of the potentialities of steam power, though he had little enough success with the engine on his second arctic expedition from 1829–33 (see Jones, 1972, *op. cit.* and Dodge, 1973, *op. cit.*).

54 McClintock, F. L. 1861. *Remarks illustrative of the sounding voyage of HMS Bulldog, in 1860.* London, pp. 12.

55 Deacon, *op. cit.* p. 231.

56 Parry, W. E. 1821. Journal of a voyage for the discovery of a north-west passage from the Atlantic to the Pacific; performed in the years 1819–20 in His Majesty's Ships *Hecla* and *Griper*. Murray, London, pp. 310 (p. 30).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